RING SEALING ARRANGEMENT FOR AN INDIRECTLY HEATED ROTARY KILN

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims priority from German patent application Serial No. 20302000.6 filed on February 8, 2003.

FIELD OF THE INVENTION

The present invention refers to a ring sealing arrangement for an indirectly heated rotary kiln.

BACKGROUND OF THE INVENTION

Indirectly heated rotary kilns typically comprise a rotating tube, generally surrounded by a bowl-shaped heating tunnel. Usually, the rotating rube is not completely surrounded by the tunnel, but rather projects from the tunnel on both front sides. Within the heating tunnel, heated gas is conducted through the heating tunnel, in order to provide the energy for the chemical and/or thermal processes taking place in the rotating tube. To this end, the heating tunnel has one or more inlets and outlets for the heating medium.

The rotating tube must be sealed off with respect to the front sides of the heating tunnel, so that the heating medium cannot flow out of the front of the heating tunnel and/or so that the surrounding air cannot flow into the heating tunnel. An escape of the heating medium would reduce the efficiency of the heating process within the heating tunnel. Furthermore, escape of the heating medium would unnecessarily and undesirably subject areas lying outside the tunnel to the considerable heat of the heating medium. An efficient sealing is particularly important if flue gas or other heat source is used as the heating medium. An undesired escape of the heating medium would then also result in environmental pollution. Moreover, an undesired flow of ambient air into the heating tunnel leads to further loss in heating efficiency.

Usually, rotating tube-circumferential seals comprise segments of cast iron or a carbide-carbon fiber mixture. As a rule, they are pressed on the

rotating drum via a cable feed loaded with weights. However, disadvantages of cast iron segments include a particularly high degree of abrasion between the segments and the tube and lack of a qualified seal at the joints of the segments. Segments made of a carbide-carbon fiber mixture tend to fracture because of their brittleness. This in turn requires that they frequently must be replaced, which leads to idle or down times for the kiln.

A significant concern regarding circumferential seals for heating tunnels, is the proper selection of application pressure for the seal. If the application pressure is too high, this leads to an intensified abrasion on the segments and/or the rotating tube. If the application pressure is too low, then this leads to the entry of secondary air from the surroundings, or the exit of heating medium from the kiln. Another disadvantage of currently available seals is that because of the relatively high load of the seal—the application pressures, as a rule, are 600 kN—the average service life of these seals is frequently less than a year, and in many instances no longer than six months.

In the selection of a material for a heating tunnel circumferential seal, one should consider that the heating medium of the rotary tubular kiln consists mostly of a gas which is heated to several hundred degrees, often above 1000°C, and furthermore, is oxidizing. Proper selection must take into account that even under these conditions, the seal material should have a sufficiently high stability.

German Patent No. 30 47 404 A1 describes a ring seal for a rotary kiln. The ring seal is provided as a stationary ring, which is made from a number of graphite parts, which, in part are arranged in the form of a ring, disposed alongside one another. The graphite parts are held with their inner side in place against a cylindrical rotating rube surface, which is coaxial with respect to the rotary kiln. The graphite parts rotate with the rotating tube. The pressing is achieved by a cable loop under tension at its ends, which surrounds the graphite units. The rotary kiln described in this publication, however, is not an indirectly heated rotary kiln, so that the ring seal is exposed to far lower temperatures and temperature differences. Furthermore, here the application pressure must also correspond to the aforementioned application pressure because of the material, i.e. graphite.

Accordingly, a need exists for a ring seal having increased stability for use in an indirectly heated rotary tubular kiln.

Furthermore, a need exits for a simplified ring seal in order to facilitate replacement and thereby reduce down time of the rotary kiln.

SUMMARY OF THE INVENTION

In a first aspect, the present invention provides a ring sealing assembly adapted for use in an indirectly heated rotary tubular kiln. The sealing assembly comprises a plurality of sealing segments positioned about the outer surface of a rotatable tube in the kiln. The sealing segments are positioned such that at least one of the segments overlaps an adjacent sealing segment. The plurality of sealing segments comprise a heat-resistant, lightweight sealing material. The sealing assembly also comprises at least one application pressure element positioned on the sealing segments to thereby provide a radial application pressure upon, and thus secure, the sealing segments to the tube.

In another aspect, the present invention provides a ring sealing assembly adapted for use in an indirectly heated rotary tubular kiln and positioned between a heating tunnel and a rotating tube of the kiln. The sealing assembly comprises a plurality of overlapping sealing segments that, upon application of a radial pressure against the sealing segments, forms a sealing ring on the tube. The ring sealing assembly also comprises an application pressure element disposed on a side of the plurality of overlapping sealing segments opposite from the tube. The application pressure element exerts a radial pressure on the sealing segments.

In yet another aspect, the present invention provides a ring sealing assembly for use in a rotary tubular kiln. The assembly comprises a plurality of overlapping sealing segments adapted to be positioned about an outer surface of a rotatable tube of a kiln to thereby form a sealing ring. The sealing assembly also comprises an application pressure element adapted to apply a radial pressure on the sealing ring. And, the sealing assembly comprises a cover disposed on the sealing ring. The cover defines a plurality of apertures adapted to facilitate the removal of debris from the sealing assembly.

The present invention may take form in various components and arrangements of components, and in various techniques, methods, or procedures and arrangements of steps. The referenced drawings are only for purposes of illustrating preferred embodiments, they are not necessarily to scale, and are not to be construed as limiting the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an axial schematic side view of a preferred embodiment sealing assembly without a cover, taken along section line IV-IV shown in Figure 6;

Figure 2 is a radial exterior view of a preferred embodiment sealing segment, in accordance with the present invention, taken along line A-A in Figure 1, illustrating an overlapping of adjacent sealing segments, on both sides;

Figure 3 is a front side view of the same sealing segment as shown in Figures 1 and 2;

Figure 4 is a front side view of an alternative embodiment of a sealing segment, in accordance with the present invention;

Figure 5 is a detailed perspective view of the engagement between two alternative embodiment sealing elements depicted in Figure 4; and

Figure 6 is a schematic partial cross section of a rotary tubular kiln utilizing a preferred embodiment sealing assembly in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

One objective of the present invention is to provide a ring seal with increased stability for an indirectly heated rotary tubular kiln. Another objective is to provide a simplified seal to facilitate replacement in order, for example, to reduce idle times.

To address these objectives, the present invention provides a unique ring seal assembly. The present invention ring seal assembly is preferably used in an indirectly heated rotary tubular kiln between a heating tunnel and a rotating tube. The ring seal assembly comprises a plurality of overlapping seal segments pressed against the rotating drum radially by contact pressure

elements. The segments are preferably made of a heat-resistant light construction sealing material. Preferred materials for the sealing segments include felts, and in particular, heat-resistant light weight sealing materials utilizing carbon fibers. The term "felt material" as used herein refers to materials having material fibers of the same or different length, however not an excessively short length, that are arranged in more or less great irregularity, to form a cohesive body which, as a rule, has a certain porosity, but nevertheless, is sufficiently compact. Inner cavities and channels within the sealing material and resulting body are preferably avoided. Such a material is preferably dimensionally stable and preferably includes graphite fibers and a carbon binder, the degree of compression and possible thermal treatment of the sealing material can be specified within certain limits. It is also particularly preferred if this material is coked and graphitized. In extreme cases, the material can be used up to temperatures of 3000°C. An example of a suitable material that is commercially available is a graphite adhesive felt, designated under the trademark of SIGRATHERM. This material is available in the form of self-supporting plates, cylinders, and other construction parts. A typical material density is generally, less than 1 g/cm^3. Particularly preferred densities include bulk densities of $\leq$ 0.16 g/cm^3. In any case, as used herein, the term, "light construction sealing material" is understood to be a sealing material having a density of $\leq$ 1.5 g/cm^3.

Use of the noted materials in the present invention ring sealing assemblies, has been found to, surprisingly, significantly reduce application forces otherwise necessary. This, in turn, has the effect of lengthening the service life of the ring seal.

The application pressure elements preferably form a closed ring, which encompasses the sealing segments radially and elastically on the side opposite from the rotating tube. In a preferred embodiment in this respect, the application pressure elements comprise several band sections, which form a tightening ring and are connected with one another, preferably by springs or also other elastic, tightening means. A band-shaped tightening ring distributes the application pressures required, which are, in any case, relatively small, to an advantageously large surface.

In certain sealing applications, and in accordance with the present invention, the required application pressure is substantially less than used in currently known applications. In certain embodiments, the application pressure is only 30 to 50 kN. With the use of a preferred embodiment tightening ring, as described herein, the application pressure can also be applied precisely. Unlike an application using cable tension loops with weights or the like on their ends, the preferred embodiment sealing segments are pressed in a uniform radial manner on the rotating tube, with little static friction.

A significant feature of the light construction sealing materials described herein is that such materials do not exert excessive abrasion forces on the rotating tube. In a preferred embodiment of the ring sealing assembly, the sealing segments are made of material which has a polishing effect on the rotating tube. In this way, the rotating tube is less impaired, as compared to currently known sealing assemblies. Furthermore, use of the present invention ring sealing assemblies reduce the surface roughness of the sealing surface of the rotating rube, which improves the sealing and thus further reinforces the seal tightness. As a result of the reduced surface roughness of the rotating tube, the wear of the sealing assembly is also reduced, which further increases or improves the service life and sealing characteristics of the sealing assembly. A carbon fiber felt is particularly preferred as a material for this purpose.

A preferred embodiment ring sealing assembly in accordance with the present invention is shown in Figure 1. The preferred sealing assembly 1 comprises a ring of sealing segments 10, which surrounds the rotating tube 20 of an indirectly heatable rotary tubular kiln. The sealing segments 10 are preferably formed from a light construction sealing material, which most preferably has a heat resistance of at least 280°C, and for example greater than 1000°C. Preferably, the sealing segments 10 are formed from a material which is also heat-resistant in an oxidizing atmosphere. Thus, there are great selection possibilities in the choice of the heating medium for the rotary tubular kiln. A particularly preferred material is high-temperature carbon fiber felt, as previously described. In certain applications, a graphite hard felt may be used, which can be additionally coated with a graphite film having a

thickness of less than or equal to about 0.5 mm (such as coating 10C as shown in Figure 6) on the side surface facing the heating tunnel. A coating of the sealing surfaces 14C and/or 14D as shown in Figure 6 with lubricating promoters, such as graphite paste, simultaneously serves to also increase tightness.

As shown in Figure 2, a preferred sealing segment 10 has two overlapping projections 12. When utilizing the segments in a sealing assembly, the overlapping projections 12, 12A or 12, 12B overlap adjacent sealing segments 10, 10A or 10, 10B extensively and form contact surfaces 14A and 14B. A sealing segment thereby preferably overlaps the adjacent segments, on the tunnel side and also away from the tunnel. As can be seen in Figure 3, these overlapping projections can be rectangle-like circular segment sections. However, other embodiments are also included in the present invention, such as shown in Figure 4, where a sealing element having a graduated overlapping projection 12 is shown. A sealing element can also comprise, however, overlapping projections with a gradual graduation. Figure 5 illustrates a perspective view of the engagement between two sealing elements from Figure 4.

Upon incorporation in a rotary tubular kiln, and during operation of the kiln, the sides of the sealing elements 10, facing the rotating tube, may be partially or fully rubbed or otherwise contacted by the rotating tube 20. Since the sealing elements 10 are radially pressed against the rotating tube 20, the sealing segments 10, 10A and 10, 10B move somewhat toward one another with wear and the contact surface 14A and 14B is increased. This configuration and arrangement of the sealing elements retains the complete functional capacity of the sealing assembly.

Figure 1 illustrates a ring comprising 8 sealing segments. The number of sealing segments, however, can vary, depending on the requirement and size of the rotary tubular kiln. The number of sealing segments, however, should be kept as low as possible. Generally, the preferred number of sealing segments is approximately between 6 and 12.

According to Figure 1 and in this respect a preferred embodiment, the sealing segments are identical in size, shape, and form, at least when the sealing assembly is first used. This ensures a uniform sealing of the rotating

tube 20. However, the present invention includes embodiments of the sealing assembly in which at least not all sealing segments are identical. For example, a sealing assembly may comprise one or more larger and/or smaller alternating segments or the segments may otherwise vary.

Preferably, on their side opposite from the rotating tube, the sealing segments 10 are surrounded by one or more application pressure elements 30, which press the sealing segments 10 radially against the rotating tube 20. The application pressure elements 30 are preferably designed as a closed ring, which elastically encompasses the segments radially on their side opposite from the rotating tube. Preferably, the sealing ring – as shown in Figure 1 – comprises several flat band-shaped sections 32, which are bound with one another, especially by springs 34, and thus form a tightening ring. This ensures a uniform radial application pressure over the entire rotating tube circumference. Instead of springs, it is also possible to use other elastic tightening means.

Alternately, however, any application pressure elements can be used, which provide a radial application pressure of the sealing segments against the rotating tube. One possible alternative application pressure element would be, for example, a flat band, completely wrapping the sealing segment ring, with ends which overlap one another and which, in turn – for example, via cable pulls – is held under tension. In the same way, the sealing segments can also be radially pressed via these encompassing tension cables.

The application pressure elements can, on the one hand, lie on or otherwise contact the sealing segments, as can be seen in Figure 6. A suitable recess can also be provided. In a preferred sealing configuration, the recess retains the application pressure element or elements. By selection of a suitable width for the sealing segment, several recesses can also be provided.

The preferred sealing segments are usually covered with a cover and/or guide on their side opposite from the rotating tube. This cover and/or guide preferably has slits or recesses, that allow the rubbings of the seal or sealing segments or other debris to be readily removed or otherwise escape from the sealing, for example, by dropping or falling from the sealing

assembly. This prevents rubbings from becoming lodged between the overlapping projections and impairing the mobility of the projections or even blocking the sealing segments. If relatively large portions or regions of the side of the sealing segments, opposite from the rotating tube, are covered by the application pressure elements, they preferably also contain guides and/or slits.

Although not necessarily to scale, Figure 6 is a longitudinal sectional view through the preferred embodiment of an indirectly heatable rotary tubular kiln with a preferred embodiment sealing assembly installed therein. A first holder 42 is placed on a heating tunnel 40, on its front end side. This holder is separated from a second holder 44 by a spacer 46. The two holding rings are thereby positioned to a certain radial distance from the rotating tube 20. The spacer 46 is positioned in such a way, at a distance from the rotating tube, that there is sufficient space for the sealing segments 10 and the application pressure element 30 between the rotating tube and the spacer 46. If the spacer, as shown in Figure 6, is somewhat wider than the sealing segments 10, the sealing segments 10 are pressed against the heating tunnel-side holding rings 42 by means of one or more application pressure elements. This can be done, for example, via one or more adjustment screws 48 arranged in the holding ring 44. However, all other application pressure systems which would enable a sealing placement of the sealing on a front surface are also included within the present invention. Thus, for example, the width of the spacer 46 can be dimensioned exactly so that it corresponds to the width of the sealing segments. If the sealing segment material can be compressed, the width of the sealing in operation can also be determined by the width of the spacer 46, in that the sealing segments are pressed in between the holding rings. In addition, the holder 42 can be part of the heating tunnel 40. The sealing segments 10 must, in any case, be positioned on the heating tunnel 40, so that the heating medium found in its interior, which flows toward the sealing segments 10 along the rotating tube axis in the direction of arrow B, cannot flow laterally around the sealing segments and thus cannot be introduced into the environment 52.

Explanation of symbols

1 Ring sealing arrangement
10 Sealing segment
10A Sealing segment
10B Sealing segment
10C Coating
12 Overlapping projection
12A Sealing segment
12B Overlapping projection
14A Contact surface
14B Contact surface
14C Sealing surfaces
14D Sealing surfaces
20 Rotating tube
30 Application pressure element
32 Flat band-like sections
34 Spring
36 Tension cable
40 Heating tunnel
42 First holder
44 Second holder
46 Spacer
48 Adjustment screw
50 Interior space
52 Environment
d Distance

The aforementioned and the claimed components, to be used in accordance with the present invention and described in the embodiment examples, are not subject to any special conditions in their size and shaping, material selection, and technical design, so that selection criteria known in the application area can be used without limitation.

The foregoing description is, at present, considered to be the preferred embodiments of the present invention. However, it is contemplated that various changes and modifications apparent to those skilled in the art, may be made without departing from the present invention. Therefore, the foregoing

description is intended to cover all such changes and modifications encompassed within the spirit and scope of the present invention, including all equivalent aspects.